



NIOSH
Fire Fighter Fatality Investigation
and Prevention Program

Death in the line of duty...

A Summary of a NIOSH fire fighter fatality investigation

December 7, 2000

Driver/Operator Dies at a Motor Vehicle Fire - Wisconsin

SUMMARY

On February 10, 1998, a 50-year-old male Driver/Operator responded to a motor-vehicle fire. After stretching a 50-foot section of 5-inch supply hose to a hydrant and returning to the Engine to retrieve handtools, the victim had a witnessed collapse. Despite cardiopulmonary resuscitation (CPR) and advanced cardiac life support (ACLS) administered on the scene and at the hospital, the victim died. The autopsy, performed by the Deputy Chief Medical Examiner, showed a large heart (cardiomegaly) and only moderate coronary artery disease (CAD). The death certificate, completed by the County Coroner, listed "Myocardial infarction" as the immediate cause of death, due to "severe atherosclerotic cardiovascular disease."

Other agencies have proposed a three-pronged strategy for reducing the risk of on-duty heart attacks and cardiac arrests among fire fighters. This strategy consists of (1) reducing physical stress on fire fighters, (2) screening to identify and subsequently rehabilitate high-risk individuals, and (3) encouraging increased individual physical capacity. Issues relevant to this Fire Department include

- Fire fighters should have annual medical evaluations to determine their medical ability to perform duties without presenting a significant risk to the safety and health of themselves or others.
- Exercise stress tests should be incorporated into the fire department's medical evaluation program.
- Fire fighters should be cleared for duty on an annual basis by a physician knowledgeable about the physical demands of fire fighting and the various components of NFPA 1582, Medical Requirements for Fire Fighters.

- Fire fighters should be provided with medical evaluations to determine their fitness to wear self-contained breathing apparatus (SCBA).
- Reduce risk factors for cardiovascular disease and improve cardiovascular capacity by offering a wellness/fitness program for fire fighters. Phase in a mandatory wellness/fitness program for fire fighters to reduce risk factors for cardiovascular disease and improve cardiovascular capacity.

INTRODUCTION AND METHODS

On February 10, 1998, a 50-year-old male Driver/Operator lost consciousness after stretching a supply hose to a hydrant. Despite CPR and oxygen administered by crew members, and ACLS administered by the squad crew and in the emergency department, the victim died. NIOSH was notified of this fatality by the United States Fire Administration. On March 15, 2000, NIOSH contacted the affected Fire Department to initiate the investigation. On April 10, 2000, a Safety and Occupational Health Specialist and an

The **Fire Fighter Fatality Investigation and Prevention Program** is conducted by the National Institute for Occupational Safety and Health (NIOSH). The purpose of the program is to determine factors that cause or contribute to fire fighter deaths suffered in the line of duty. Identification of causal and contributing factors enable researchers and safety specialists to develop strategies for preventing future similar incidents. To request additional copies of this report (specify the case number shown in the shield above), other fatality investigation reports, or further information, visit the Program Website at:

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Epidemiologist from the NIOSH Fire Fighter Fatality Investigation Team traveled to Wisconsin to conduct an on-site investigation of the incident.

During the investigation NIOSH personnel interviewed

- The Fire Chief
- Crew members on duty with the victim
- The victim's former wife

During the site visit NIOSH personnel reviewed the

- Fire Department incident report
- Fire Department policies and operating guidelines
- Fire Department training records
- Fire Department annual report for 1998
- Emergency medical service (ambulance) report
- Hospital's records of the resuscitation effort
- Past medical records of the deceased

INVESTIGATIVE RESULTS

Incident. On February 10, 1998, at 1436 hours, the involved Fire Department was dispatched to a fire in a passenger vehicle. Engine 2 (Lieutenant, Driver/Operator, and one Fire Fighter), Engine 1 (Captain and the Driver/Operator [the victim]), and Squad 1 (two Paramedics) responded and arrived on the scene at 1437 hours. As soon as Squad 1 arrived, they were dispatched for a rescue call and departed the fire scene. At the fire scene, Engine 2 was utilized as the attack pumper. The Lieutenant and one Fire Fighter, wearing full turnout gear with self-contained breathing apparatus (SCBA) (on-air), removed the preconnected 1¾-inch hose and advanced to attack the fire. The victim, wearing full turnout gear, stretched a 50-foot section of 5-inch supply hose to a nearby hydrant for hookup, in case the need for more water arose. The fire was extinguished and the Captain advised the victim that the hydrant connection was not necessary. The victim then donned an SCBA and, after turning on the SCBA's air supply, walked toward Engine 2 to retrieve handtools to assist in overhauling the fire

vehicle. As he neared Engine 2, the victim tripped over a hoseline and fell to the ground. The Driver/Operator of Engine 2 got down from the Engine's pump operator platform and assisted him in standing up. The Driver/Operator asked the victim if he was OK; the victim nodded his head affirmatively. The Driver/Operator got back onto Engine 2 to monitor the pump controls, and the victim sat down on Engine 2's running board. The Lieutenant noticed the victim sitting down and alerted the Captain, who walked to the victim to see if something was wrong. The victim was unresponsive. The Captain alerted the Lieutenant, another Fire Fighter, and the Engine 2 Driver/Operator that help was needed. They assisted the victim to the ground and began to remove his SCBA and turnout gear. The victim was cyanotic and trying to open his eyes. The victim then stopped breathing. The Captain notified Dispatch that a man was down and not breathing. Dispatch notified Squad 2 and a neighboring squad. On-scene crew members, trained in CPR, assessed the victim and found him to be unresponsive, not breathing, and pulseless. Cardiopulmonary resuscitation (CPR) (chest compressions with assisted ventilations via bag-valve-mask and 100% oxygen) was begun and the victim was intubated by a Fire Fighter/Paramedic. A Fire Fighter and a Lieutenant arrived in their privately-owned vehicles to assist. Squad 2 (one Emergency Medical Technician [EMT]) arrived. A heart monitor from Squad 2 was attached to the victim at 1449 hours and revealed ventricular fibrillation (V.Fib.). Three electrocardioversions (shocks) were administered with no change in patient status. Intravenous access was obtained and medications consistent with ACLS protocols were followed. The neighboring squad arrived soon after.

After being loaded into the ambulance, the victim was rechecked for a pulse, found to be pulseless and not breathing, and CPR with assisted ventilations via bag-valve mask and oxygen continued. The ambulance departed the scene at 1507 hours. En route to the hospital, the monitor again revealed



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V.Fib., and three more shocks were delivered. The heart monitor then revealed asystole and CPR continued. The ambulance arrived at the hospital at 1514 hours. ACLS protocols were continued in the emergency department for 7 minutes until the victim was pronounced dead at 1521 hours.

Medical Findings. The death certificate, completed by the County Coroner, listed “myocardial infarction” as the immediate cause of death. The death certificate also listed “severe atherosclerotic cardiovascular disease” as a significant other condition. His blood carbon monoxide level was not assessed.

Medical records indicated that the victim had four risk factors for coronary artery disease (CAD): male gender, smoking, high cholesterol, and obesity/physical inactivity. In December 1987, the victim underwent five-artery Coronary Artery Bypass Graft Surgery (CABG) after a cardiac catheterization showing severe three-vessel disease (total occlusion of the circumflex, 70%, 90%, and 80% of the left anterior descending, 60-70% occlusion of the right coronary artery) and mild left ventricular impairment (ejection fraction=60%). Over the ensuing 10 years the victim had six Thallium Exercise Stress Tests (EST) ordered by his private physician. All tests indicated defects that could be explained by past myocardial infarctions (MIs) and/or ischemia. At the most recent test, performed on February 20, 1996, the victim reached Stage IV and 13.5 METS in the Bruce protocol. ST segment depression was noted, and the test was read as abnormal; however, it was unclear from the summary whether the ST segment depression was a new change. In addition, the thallium scan was also abnormal, but whether the perfusion defects were new, or represented old heart attacks versus persistent ischemia, is unclear from the summary.

Pertinent findings from the autopsy, performed by the Deputy Chief Medical Examiner on February 10, 1998, are listed below:

- Severe arteriosclerotic heart disease
High-grade atheromatous plaques of up to 100% occlusion of the left anterior descending and the right coronary arteries
- Large remote myocardial infarct in the lateral wall of the left ventricle
- Three graft vessels
- Cardiomegaly (enlarged heart) (750 gms)

DESCRIPTION OF THE FIRE DEPARTMENT

At the time of the NIOSH investigation, the Fire Department consisted of 44 uniformed personnel (career and paid/call) and served a population of 20,000 residents for fire emergencies and 24,000 residents for rescue emergencies, in a geographic area of 11 square miles (fire) and 19 square miles (rescue) respectively. There are two fire stations. Crew members work the following tour of duty: 24 hours on duty and 24 hours off duty for three tours, then off duty for 4 days. Each 24-hour shift begins at 0700 hours. The emergency medical service is a function of the Fire Department.

In 1998, the Department responded to 1,432 calls: 1,116 rescue (EMS) calls, 209 fire calls (26 structure fires, 11 vehicle fires, 6 dumpster fires, 3 grass/brush fires, 10 other fires, 4 mutual-aid fire calls, 107 false alarms, 11 hazardous-materials calls, 21 other hazardous responses, and 10 calls not categorized), 28 mutual-aid extrication calls, and 79 service runs. The day of the incident, the victim, a career Fire Fighter, reported to work at 0700 hours, checked out his pumper, and attended classroom training. The incident described above was the victim's first response the day he collapsed.

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Training. The Fire Department requires that all new fire fighters be a state-certified Fire Fighter II (or achieve an Associate's degree), an EMT-Basic, and pass a skill test before being selected as a recruit fire fighter. Once selected, the recruit Fire Fighter must pass a physical agility test and a preemployment physical examination before being fully hired. The Fire Fighter then performs recruit training for a minimum of 80 hours. Once recruit training is completed, the Fire Fighter is assigned to a shift. Subsequent training is provided monthly on each shift. The Fire Fighter must then complete a 60-hour, state-certified pumper Driver/Operator course and a 21-hour aerial Driver/Operator course within 12 months of appointment. There is no state requirement for annual recertification. The victim was certified as a Fire Fighter II, EMT-B, and Driver/Operator, and he had 26 years of fire-fighting experience.

Preemployment/Preplacement Evaluations. The Department requires a preemployment/preplacement medical evaluation for all new hires, regardless of age. Components of this evaluation include

- A complete medical history
- Height, weight, and vital signs
- Physical examination
- Vision test
- Audiometry
- Blood Tests: HAZMAT panel (blood sugar, creatinine, BUN, SGOT, SGPT, GGT, CBC with manual differential), Rapid Drug Screen 8 panel (Marijuana, Cocaine, PCP, Opiates, Amphetamines, Barbiturates, Benzodiazepines, Methamphetamine)
- Back screen Level 5 (100-lb lift)
- Urine Tests: Urinalysis, Dipstick
- Chest X-ray (2 view)
- Electrocardiogram (EKG)
- Titmus vision complete exam
- Pulmonary function test
- Respiratory clearance exam

These evaluations are performed by a contract physician hired by the City Human Resources Office. Once this evaluation is complete, a decision regarding medical clearance for fire-fighting duties is made by the contract physician based upon the physician's own criteria.

Periodic Evaluations. The Department has no requirement for periodic physical examinations and thus provides none. The Department also does not require a medical clearance evaluation to wear a respirator. No specific Fire Department programs were in place to enhance the cardiovascular/respiratory fitness of the fire fighters. All fire fighters must pass a quarterly SCBA drill.

DISCUSSION

In the United States, coronary artery disease (atherosclerosis) is the most common risk factor for cardiac arrest and sudden cardiac death.¹ Risk factors for its development include advancing age, male gender, family history of coronary artery disease, smoking, high blood pressure, high blood cholesterol, obesity/physical inactivity, and diabetes.² The victim had several of these risk factors (male gender, smoking, high cholesterol and obesity/physical inactivity), and he was found to have CAD in 1987 for which he had a coronary artery bypass graft.

The narrowing of the coronary arteries by atherosclerotic plaques occurs over many years, typically decades.³ However, the growth of these plaques probably occurs in a nonlinear, often abrupt fashion.⁴ Heart attacks typically occur with the sudden development of complete blockage (occlusion) in one or more coronary arteries that have not developed a collateral blood supply.⁵ This sudden blockage is primarily due to blood clots (thrombosis) forming on the top of atherosclerotic plaques.

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Blood clots, or thrombus formation, in coronary arteries are initiated by disruption of atherosclerotic plaques. Certain characteristics of the plaques (size, composition of the cap and core, presence of a local inflammatory process) predispose the plaque to disruption.⁵ Disruption then occurs from biomechanical and hemodynamic forces, such as increased blood pressure, increased HR, increased catecholamines, and shear forces, which occur during heavy exercise.^{6,7}

Fire fighting is widely acknowledged to be one of the most physically demanding and hazardous of all civilian occupations.⁸ Fire-fighting activities are strenuous and often require fire fighters to work at near maximal heart rates for long periods. The increase in heart rate has been shown to begin with responding to the initial alarm and to persist through the course of fire-suppression activities.⁹⁻¹¹ Epidemiologic studies have found that heavy physical exertion sometimes immediately precedes and triggers the onset of acute heart attacks.¹²⁻¹⁵ The victim, while wearing full turnout gear with SCBA, had stretched a 50-foot section of 5-inch supply hose (weighing approximately 60 lb) to a hydrant. This activity probably required a fair amount of physical exertion.

To reduce the risk of heart attacks and sudden cardiac arrest among fire fighters, the National Fire Protection Association (NFPA) has developed guidelines entitled "Medical Requirements for Fire Fighters and Information for Fire Department Physicians," otherwise known as NFPA 1582.¹⁶ They recommend, in addition to screening for risk factors for CAD, an exercise stress electrocardiogram (EKG), otherwise known as an exercise stress test (EST). The EST is used to screen individuals for CAD. Unfortunately, it has problems with both false negatives (inadequate sensitivity) and false positives (inadequate specificity), particularly for asymptomatic individuals (individuals without symptoms suggestive of angina).¹⁷⁻¹⁸ This has led other expert groups to **not** recommend EST for

asymptomatic individuals without risk factors for CAD.^{19, 20}

When these asymptomatic individuals **have** risk factors for CAD, however, recommendations vary by organization. The American College of Cardiology/American Heart Association (ACC/AHA) identifies two groups for EST: (1) men over the age of 40 with a history of cardiac disease (as a screening test prior to beginning a strenuous exercise program), and (2) men over age 40 with one or more risk factors.¹⁹ They define five risk factors for CAD: hypercholesterolemia (total cholesterol greater than 240 mg/dL), hypertension (systolic greater than 140 mm Hg or diastolic greater than 90 mm Hg), smoking, diabetes, and family history of premature CAD (cardiac event in first-degree relative less than 60 years old).¹⁹ The U.S. Preventive Services Task Force (USPSTF) does not recommend EST for asymptomatic individuals, even those with risk factors for CAD; rather, they recommend the diagnosis and treatment of modifiable risk factors (hypertension, high cholesterol, smoking, and diabetes).²⁰

These recommendations change for individuals who might endanger public safety if an acute episode were experienced or for those who require high cardiovascular performance such as police and fire fighters. The National Fire Protection Association (NFPA) recommends EST for fire fighters without CAD risk factors at age 40 and for those with one or more risk factors at age 35.¹⁶ NFPA considers risk factors to be family history of premature (less than age 55) cardiac event, hypertension, diabetes mellitus, cigarette smoking, and hypercholesterolemia (total cholesterol greater than 240 mg/dL or HDL cholesterol less than 35 mg/dL).¹⁶ The EST should then be performed on a periodic basis, at least once every 2 years.¹⁶ The ACC/AHA indicates that data are insufficient to justify periodic exercise testing in people involved in public safety; however, as mentioned previously, they recommend that men over age 40 with a history of cardiac disease be screened

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before beginning a strenuous exercise program.¹⁹ Fire suppression activities involve strenuous physical activity; therefore, the ACC/AHA seem to be making a distinction between those already engaged in strenuous physical activity (conditioning), and those **beginning** a strenuous exercise program. The USPSTF indicates that evidence is insufficient to recommend screening middle-age and older men or women in the general population; however, “screening individuals in certain occupations (pilots, truck drivers, etc.) can be recommended on other grounds, including the possible benefits to public safety.”²⁰

The Department did not conduct periodic medical evaluations. NFPA recommends a yearly physical evaluation to include a medical history, height, weight, blood pressure, and visual acuity test.¹⁴ NFPA recommends a thorough evaluation to include vision testing, audiometry, pulmonary function testing, a complete blood count, urinalysis, and biochemical (blood) test battery be conducted on a periodic basis according to the age of the fire fighter (less than 30, every 3 years; 30 to 39, every 2 years; over 40 years, every year). Thus, disagreement remains regarding whether asymptomatic fire fighters should have ESTs.

In 1997, the NFPA updated Standard 1582, Medical Requirements for Fire Fighters.¹⁶ This voluntary industry standard specifies minimum medical requirements for candidates and current fire fighters. NFPA 1582 considers individuals with CAD (history of myocardial infarction, coronary artery bypass surgery, or coronary angioplasty) to be a “Category B Medical Condition.” A Category B Medical Condition is defined as “a medical condition that, based on its severity or degree, **could** (our emphasis) preclude a person from performing as a fire fighter in a training or emergency operational environment by presenting a significant risk to the safety and health of the person or others.” Appendix A of the Standard contains guidance for when to

preclude a fire fighter with CAD from engaging in fire-fighting activities. Appendix A states that “persons at mildly increased risk for sudden incapacitation are acceptable for fire fighting. Mildly increased risk is defined by the presence of each of the following:

- Normal left ventricular ejection fraction
- Normal exercise tolerance, >10 metabolic equivalents (METS)
- Absence of exercise-induced ischemia by exercise testing
- Absence of exercise-induced complex ventricular arrhythmias
- Absence of hemodynamically significant stenosis on all major coronary arteries (≥ 70 percent lumen diameter narrowing), or successful myocardial revascularization.”

Based on this Driver/Operator’s EST in February 1996, it is unclear whether he met the third criterion.

RECOMMENDATIONS AND DISCUSSION

The following recommendations address health and safety generally. This list includes some preventive measures that have been recommended by other agencies to reduce the risk of on-the-job heart attacks and sudden cardiac arrest among fire fighters. These recommendations have not been evaluated by NIOSH but represent published research findings or consensus votes of Technical Committees of the National Fire Protection Association or labor/management groups within the fire service. In addition, they are presented in a logical, programmatic order and are not listed in a priority manner.

Recommendation #1: Fire fighters should have annual medical evaluations to determine their medical ability to perform duties without presenting a significant risk to the safety and health of themselves or others.

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Guidance regarding the content and scheduling of periodic medical examinations for fire fighters can be found in NFPA 1582: Standard on Medical Requirements for Fire Fighters,¹⁶ and in the report of the International Association of Fire Fighters/International Association of Fire Chiefs (IAFF/IAFC) wellness/fitness initiative.¹⁹ The Department is not legally required to follow any of these standards. Nonetheless, we recommend the City and Union **negotiate** the content and frequency of the annual medical evaluation to be consistent with the NFPA guidelines.

In addition to providing guidance on the frequency and content of the medical evaluation, NFPA 1582 provides guidance on medical requirements for persons performing fire-fighting tasks. Applying NFPA 1582 involves legal issues, so it should be carried out in a **confidential, nondiscriminatory** manner. Appendix D of NFPA 1582 provides guidance for fire department administrators regarding legal considerations in applying the standard.

Applying NFPA 1582 also involves economic issues. These economic concerns go beyond the costs of administering the medical program; they involve the personal and economic costs of dealing with the medical evaluation results. NFPA 1500: Standard on Fire Department Occupational Safety and Health Program addresses these issues in Chapter 8-7.1 and 8-7.2.²¹

The success of medical programs hinges on protecting the affected fire fighter. The fire department must (1) keep the medical records confidential, (2) provide alternate-duty positions for fire fighters in rehabilitation programs, and (3) if the fire fighter is not medically qualified to return to active fire fighting duties, provide permanent alternate-duty positions or other supportive and/or compensated alternatives. These legal and economic repercussions may be particularly difficult for small fire departments and could negatively

impact the ability to recruit and retain needed fire fighters.

Recommendation #2: Exercise stress tests should be incorporated into the Fire Department's medical evaluation program.

NFPA 1582, Standard on Medical Requirements for Fire Fighters and Information for Fire Department Physicians, and the International Association of Fire Fighters/International Association of Fire Chiefs (IAFF/IAFC) wellness/fitness initiative both recommend at least biannual EST for fire fighters.^{16,22} They recommend that these tests begin at age 35 for those with CAD risk factors and at age 40 for those without CAD risk factors. These EST will undoubtedly increase the costs associated with the medical evaluations. To some extent these costs could be offset by reducing the frequency of other tests included in the current annual examination. The EST could be conducted by the fire fighter's personal physician or the Department's contract physician. If the fire fighter's personal physician conducts the test, the results must be communicated to the City contract physician, who should be responsible for decisions regarding medical clearance for fire-fighter duties.

Recommendation #3: Fire fighters should be cleared for duty on an annual basis by a physician knowledgeable about the physical demands of fire fighting and the various components of NFPA 1582, Medical Requirements for Fire Fighters and Information for Fire Department Physicians.

If the fire fighter's personal physician conducts the test, the results must be communicated to a City contract physician, who should be responsible for decisions regarding medical clearance for fire-fighter duties. If no City contract physician is available, the personal physician should be made aware of the stresses that fire fighters are subjected to while

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performing their duties and of NFPA 1582 and the guidelines for physical examinations of fire fighters.

Recommendation #4: Fire fighters should be provided with medical evaluations to determine their fitness to wear self-contained breathing apparatus (SCBA).

In 1997, OSHA published its revised Respiratory Protection Standard.²³ This Standard, among other things, requires that a medical evaluation of workers who wear SCBA be performed by a physician or other licensed health-care professional. This evaluation could consist of a screening questionnaire to ascertain if additional medical evaluations or a medical examination is warranted. Because Wisconsin does not have an Occupational Safety and Health Administration (OSHA)-approved state plan, its state and municipal employees, such as fire fighters, are not covered under the Occupational Safety and Health Act. Therefore, State, County, or City fire departments in Wisconsin are NOT required to comply with OSHA standards. Nonetheless, we recommend voluntary compliance with the Respiratory Protection Standard to ensure that fire fighters can safely wear SCBA.

Recommendation #5: Reduce risk factors for cardiovascular disease and improve cardiovascular capacity by offering a wellness/fitness program for fire fighters. Phase in a mandatory wellness/fitness program for fire fighters to reduce risk factors for cardiovascular disease and improve cardiovascular capacity.

NFPA 1500, Standard on Fire Department Occupational Safety and Health Program, requires a wellness program that provides health-promotion activities for preventing health problems and enhancing overall well-being.²¹ In 1997, the International Association of Fire Fighters (IAFF) and the International Association of Fire Chiefs (IAFC) joined in a comprehensive Fire Service Joint Labor

Management Wellness/Fitness Initiative to improve fire-fighter quality of life and maintain physical and mental capabilities of fire fighters. Ten fire departments across the United States joined this effort to pool information about their physical fitness programs and to create a practical fire service program. They produced a manual and a video detailing elements of such a program.²² The Fire Department and the Union should review these materials to identify applicable elements for their Department. Other large-city negotiated programs can also be reviewed as potential models.

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INVESTIGATOR INFORMATION

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